Volume 4 NOVEMBER 21, 1929 Number 5

BULLETIN

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OF THE

AMERICAN PHYSICAL SOCIETY

PROGRAM

OF THE

STANFORD MEETING

AT THE

STANFORD UNIVERSITY

STANFORD UNIVERSITY, CALIFORNIA

DECEMBER 7, 1929

PUBLISHED BY THE AMERICAN PHYSICAL SOCIETY
SIX ISSUES EACH YEAR

The American Physical Society

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AMERICAN PHYSICAL SOCIETY

Published six times per year

Subscription price: $1.00 per year.

The Bulletin of the American Physical Society is published six times a year during the months of February, April, June, November (2 issues), and December at 450 Ahnaip Street, Menasha, Wisconsin.

Address correspondence to Secretary W. L. Severinghaus, Columbia University, New York N.Y.

Entered at the post office at Menasha, Wisconsin, as second class matter.

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STANFORD MEETING, DECEMBER 7, 1929

The 160th regular meeting of the American Physical Society will be held at Stanford University, Stanford University, California, in the main lecture room of the Physics Department on Saturday, December 7, 1929.

Titles and abstracts are given in the following pages in order of presentation.

Morning session, 10 o'clock—papers 1–11.

Afternoon session, 2 o'clock—supplementary program.

Abstracts: Titles and abstracts of the papers to be presented are given in the following pages. These abstracts have not been corrected by the authors. After correction the abstracts of the Physical Society papers will be published in the Physical Review. Authors should send corrections to the editor of the Physical Review.

Other meetings for the current season are as follows:

161. Annual Meeting, Des Moines, December 30–31, 1929–January 1, 1930.
162. February 21–22, 1930. New York.
163. April 18–19, 1930. Washington.
164. June meeting on the Pacific Coast. (Place and date not yet determined.)

L. B. LOEB, *Local secretary for the Pacific Coast*
University of California, Berkeley, Calif.

PROGRAM

1. The blue-green absorption bands of Li_2. A. HARVEY AND F. A. JENKINS. *University of California.*—The absorption spectrum of lithium vapor contained in a nickel tube, and maintained at temperatures varying from 650°C to 900°C, has been examined under both high and low dispersion. Employing a tube 1 m long at the lower temperatures, we have identified the band heads due to the less abundant isotope molecule, Li^6 Li^7, which accompany the (1,0), (2,0) and (3,0) bands of the stronger Li^7 Li^7 system. The isotope displacements agree with their calculated values within the error of measurement (calculated: 2.08, 4.32, 6.30A; observed: 2.06, 4.47, 6.37A. This checks the assignment of vibrational quantum numbers and the equations for the vibrational energy previously given (Phys. Rev. **34,** 1286 (1929)). Measurements of the band heads are necessarily inaccurate, because the head occurs at a low rotational quantum number. More satisfactory data may be obtained with the band lines, which are well resolved in the first order of the 15-foot grating. It has been possible to establish definitely that each band has the three-branch structure expected for a $^1\pi \rightarrow {}^1\Sigma$ transition, by using an unambiguous graphical method due to Loomis (Phys. Rev. **32,** 223 (1928)). Quantitative measurements will be made of the alternating intensities previously reported, and the rotational isotope effect in the (0,0) band investigated.

2. Why does molecular hydrogen reach equilibrium so slowly? HARVEY HALL AND J. R. OPPENHEIMER, *University of California.*—The uncatalyzed conversion ortho-para in gaseous hydrogen may be investigated quantum mechanically. A molecule of parahydrogen may be converted by collision with any other molecule to orthohydrogen; but the probability for this conversion is small, because the conversion is induced by the very small interaction of nuclear magnetic moment with the magnetic moment of the rotating molecule. Furthermore, two molecules of parahydrogen may be converted to orthohydrogen by the interchange of nuclei between the molecules; this effect depends upon the overlapping of the wave functions for the nuclei which interchange; and its relative probability may be shown to be small, in comparison with the probability of a gas kinetic collision, of the order

$$e^{-(M/m)1/2}$$

where M is the mass of the proton, and m that of the electron. The consideration of both effects shows that parahydrogen should, at N.P.T., be half converted to orthohydrogen in a period of the order of 10^7 seconds.

3. The Carbon isotope, Mass 13. A. S. KING AND R. T. BIRGE. *Mount Wilson Observatory and University of California.*—A systematic study of the carbon isotope is in progress, with the following results to date. (1) The isotope has been found in the 2–0 (λ4382) band of C_2, and in the 1–0 (λ3590) band of CN, in addition to the original 1–0 band of C_2 and 0–0 band of CN. (2) Much stronger exposures of the 1–0 C_2 isotope band (λ4744) have been obtained, in both first and second order spectra, showing at least fifteen lines suitable for measuring the isotope shift. (3) The large perturbation in line P_3 (λ4731.8) of the 1–0 C_2 band, does *not* appear in the corresponding isotope line, in agreement with theory. (4) The "staggering" in the main 1–0 C_2 band, caused by the absence of alternate rotational levels, is *not* present in the isotope band, again in agreement with theory. (5) The λ4744 isotope band, as excited in the furnace, is at least ten times as strong, relative to the main band, as in the arc, where it has not as yet been observed with certainty. The relative intensity of the isotope band is thus a *function of excitation conditions,* and this fact may well invalidate all estimates of relative isotope abundance, based on relative spectral intensity.

4. The vibrational isotope effect. RAYMOND T. BIRGE. *University of California.*—Gibson (Zeits. f. Physik **50,** 692 (1928)) has formulated a beautiful method for calculating the vibrational isotope shift which is theoretically sound, and is the only accurate method available in the region of high values of the vibrational quantum number (n). The writer has added the details necessary for its precise numerical application, and has tested it on the absorption

bands of Cl_2, previously treated by Elliott (Proc. Roy. Soc. **A123,** 629 (1929)), and of ICl, previously treated by Gibson (loc. cit.) and by Patkowski and Curtis (Trans. Faraday Soc. in press). In both these cases the theory is used to determine the correct n' numbering of the bands. The present results definitely require the half quantum numbers of the new mechanics. For Cl_2 they show that Elliott's n' numbering should be decreased by two units. For ICl they show, (1) that the main absorption progression arises from the $n''=0$ level, in apparent contradiction to a temperature experiment by Gibson (indicating the $n''=1$ level) which, however, the writer believes can be otherwise explained: (2) that Gibson's n' numbering should be decreased by one unit. Both of these latter results agree with Patkowski and Curtis' conclusions, based on a less rigorous method of calculation.

5. Equivalent temperatures in the electric arc as measured by multiplet intensities. GEORGE R. HARRISON, *Standford University.*—It has been shown by Langmuir, Nottingham, and others, that probe measurements in the positive column of the electric arc indicate equivalent electron temperatures lying between 5000 and 70,000A, the electrons having a Maxwellian velocity distribution. Engwicht and the writer have previously shown that corrections corresponding to temperatures in the neighborhood of 8000A had to be applied to the intensities of multiplets having widely separated upper states when measured in the titanium arc under widely separated upper states when measured in the titanium arc under average conditions. New studies have been made of the effect of changing excitation conditions on the relative intensities of multiplets in triads, and excitation temperatures between 3000 and 15,000A have been found for the positive column of the titanium arc. The curves relating current density and electron temperature are similar to those obtained by Nottingham with the Langmuir probe for cadmium, copper, and other arcs. While probably less accurate than the probe method, the intensity method gives an excellent check on its results. The most consistent data are obtained when multiplets with common lower states are chosen, so that the most accurate self-reversal corrections can be made if required.

6. Photographic photometry in the extreme ultra-violet. PHILIP A. LEIGHTON AND GEORGE R. HARRISON, *Stanford University,*--The work of one of us (J.O.S.A.**11,** 341 (1925)) on characteristics of photographic emulsions coated with fluorescent substances when exposed to ultra-violet light has been extended to the extreme ultra-violet. Slow, medium, and fast emulsions coated with various oils have been exposed in a vacuum spectrograph under controlled conditions. Several combinations have been found which exhibit uniform contrast throughout the region 1000–3,000A, with quite uniform sensitivity. The great difficulty of producing known variations of intensity in the extreme ultra-violet makes it desirable to find photographic materials which obey the reciprocity law accurately for use in this region. The best conditions to be fulfilled appear to be: 1. Selection of an emulsion obeying the reciprocity law accurately at wave-lengths near 4,000A; 2. Coating it with a substance which fluoresces near this wave-length, does not absorb its own fluorescence light, and completely absorbs in a thin layer all light of wave-lengths 1,000–3,000A. It is shown that the behavior of a given combination of emulsion and fluorescence substance in the extreme ultra-violet can often be predicted from a knowledge of the characteristics of each in the fluorescence region.

7. The broadening of spectrum lines during early stages of spark discharges. FRANK G. DUNNINGTON AND ERNEST O. LAWRENCE. *University of California.*—The voltage across a spark gap drops to a relatively small value in 10^{-8} sec. after the beginning of the discharge. The cross-section of the discharge during periods of the magnitude of 10^{-7} sec. after break down, however, has not been observed, but there is evidence that it is small and therefore that the discharge current density is enormous. Such large initial ionic densities should be evidenced by large Stark effect broadening of spectrum lines in the early stages of sparks. Using the Beams electro-optical shutter we have photographed the light emitted by sparks during 5×10^{-7} sec. after breakdown. As expected all spectrum lines are diffuse, the spark doublets $(3d_{1,2}-4f)$ of Mg, $(3d_1-4f_1)$ $(3d_2-4f_2)$ of Cd and Zn for example, having a breadth of approximately 40A. From existing data on the Stark effect of Mg it is calculated that the average ionic field producing the here observed Stark effect broadening is about 600,000 volts/cm, and that approcimately 1/2 of the molecules in the path of the discharge are ionized. The luminosity of the metallic vapor was observed to spread from the cathode at a velocity of 1.2×10^{5} cm/sec.

8. The effective collision cross-section of cadmium and zinc atoms for slow electrons. ROBERT B. BRODE. *University of California.*—The variation with the electron velocity of the effective collision cross-section or the absorption coefficient, α, has been measured in the vapors of cadmium and zinc and found to follow a curve of the type previously found for mercury. (Proc. Roy. Soc. **125,** 134, (1929)). The cadmium curve has a maximum at about 40 volts, $\alpha = 130$, and a minimum at about 25 volts, $\alpha = 126$, followed by a steady rise with decreasing velocity to the limit of accurate measurements, 1 volt, $\alpha = 700$. The zinc curve has a very flat maximum at about 50 volts, $\alpha = 76$, a minimum at about 36 volts, $\alpha = 74$, followed by a steady rise to $\alpha = 500$ at 1 volt. As in mercury vapor a very small change in the general slope is observable in both of the curves just beyond the first resonance potential. The magnitude of the maximums are in the order; Cd, $\alpha = 125$; Zn, $\alpha = 75$ and Hg, $\alpha = 60$. Other related properties of these atoms such as the molar refractivity and the critical potentials show this same irregularity in order.

9. A direct measurement of molecular velocities. I. F. ZARTMAN, *University of California.*—The molecules whose velocities are to be measured are vaporized in an electrically heated crucible. A sharply defined molecular beam is formed by two rectangular slits, one of which is placed in the cover of the crucible, the other 3.8 cm above the crucible slit. A steel cylinder, 9.41 cm inside diameter, which is rotated by an electric motor has a slit in its periphery and supports a glass collecting plate (which has been coated with a thin uniform deposit of the substance to be investigated) on the inner face diametrically opposite the slit. The entire assembly is operated in a vacuum of less than 10^{-4} mm and at speeds varying between 120 and 240 r.p.s. The molecules in the group entering the cylinder possess a distribution of velocities. These molecules pass to the opposite side of the cylinder and are collected on the glass plate in the form of a velocity spectrum whose density is measured with a microphotometer. The velocity v of the molecules $= \pi d^2 n/S$ where d = diameter of the cylinder, n = r. p. s., and s = displacement of the molecules. Three runs taken with Bi at 800°C indicate that it vaporizes as a monatomic molecule. The displacement corresponding to the most probable speed in the beam at 120 r. p. s. is 0.7 cm. Other substances are now being investigated.

10. Experiments on the reported fine structure of the molybdenum K_β lines. SAMUEL K. ALLISON AND J. H. WILLIAMS. *University of California.*—Davis and Purks (Proc. Nat. Acad. Sci. **14,** 172, (1928)) have investigated the K-spectrum of molybdenum with a double x-ray spectrometer and obtained a complete resolution of the K_β doublet with both crystals reflecting in the second order. They report a new line $K_{\beta'}$, 24 seconds or arc (0.17 X.U.) on the long wave-length side of K_{β_1}. The intensity of this new line appears to be sbout 1/3 that of K_{β_1} An attempt has been made to study this new line using a double spectrometer with both crystals in the second order, and one in the second and one in the third order. Experiments were carried out at 42.7 kv and 45.6 kv. No positive evidence could be obtained for a satellite of K_{β_1} in the reported position. From the curves obtained it appears that if such a satellite is present at the voltages stated above, its intensity must be less than 1/10 that of K_{β_1}. An average of eight determinations of the wave-length separation of β_1 and β_3 gives $\Delta\lambda = 0.572 \pm 0.003$ X.U. Previous values obtained with the single spectrometer were 0.563 X. U. (Allison and Armstrong, Phys. Rev. **26,** 701, (1925)) and 0.565 X.U. (Larsson, Phil. Mag. **3,** 1136, (1927)).

11. The electric space charge in the lower atmosphere. JOSEPH G. BROWN, *Stanford University.*—During the past year continuous records of space charge have been obtained 7.5 meters above the earth's surface. Obolensky's method of gathering all the ions from a known volume of air and measuring the residual charge has been used. The mean value of the positive charge has been about 0.10 E. S. U. per cubic meter. This value lies between Obolensky's and Kahler's. The air was quite free from dust which gives large negative charges, or smoke which gives large positive charges. If the air is still the space charge is remarkably constant, but if in motion sudden changes occur. This fact has led to the conclusion that most variations at a given point are due to different bodies of air which have different charges. At night when the air becomes saturated the positive space charge decreases and negative charge often occurs. During rain large positive or negative charge results. The mean diurnal variation is almost the

reciprocal of the temperature variation, though there is a decided tendency to agree with the potential gradient. Sudden changes in space charge are accompanied by corresponding changes in potential gradient, though many changes in potential gradient are not accompanied by changes in space charge.

SUPPLEMENTARY PROGRAM

12. Variation of the electric potential gradient in the lower atmosphere. JOSEPH G. BROWN, *Stanford University.*—The mean electric field is characterized by a negative surface charge and a positive space charge. The mean distribution of the positive space charge can be inferred from the values of the potential gradient at different elevations, since $d^2V/dh^2 = 4\pi\rho$. Approximate computation shows that 50 percent of the charge is in the first kilometer, 18 percent in the second, etc. Variations in mean distribution will cause variations in potential gradient at any point by changing the relative magnitudes of the space charges (a) in horizontal layers and (b) in vertical columns. Expansions and convection currents will produce such changes in distribution and hence determine potential gradients. Continuous records of potential gradient and space charge have been obtained for a year 7.5 meters above the surface and their diurnal variations compared with the diurnal system of convection as inferred from the meteorological elements. In general upward currents near the surface correspond with increased charge and potential gradient, while downward correspond with decreased. General expansion and overflow above correspond with decreased charge and potential gradient, while cooling and inflow above correspond with increased. This is in agreement with the theory. Dust, smoke, and condensation are important factors but are believed to be of secondary importance in determining the mean diurnal variation.